

Acute Toxicity of Ammonia, Copper, and Pesticides to *Eurytemora affinis* and *Pseudodiaptomus forbesi*

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Background

In 2008, 96 h toxicity testing revealed several water samples in North and South Delta were toxic to *Eurytemora affinis*



■ Mean survivals in North Delta:

■ Hood:	5 %
■ 711:	17 %
■ Cache Lindsey:	28%
■ Light55:	33%

■ Mean survivals in South Delta:

■ 815:	52%
■ 902:	43%
■ 915:	65%

■ Mean survivals in Suisun Bay >88%

Anthropogenic Stressors

■ Unionized Ammonia

- Hood 9-25 $\mu\text{g/L}$
- 711 11-29 $\mu\text{g/L}$
- Cache-Lindsey 11-13 $\mu\text{g/L}$
- Light55 6-11 $\mu\text{g/L}$

■ Copper

- 711 2.16-3.01 $\mu\text{g/L}$
- Cache-Lindsey 4.10-4.41 $\mu\text{g/L}$
- 902 3.47 $\mu\text{g/L}$

■ Bifenthrin

- 711 0.001 $\mu\text{g/L}$
- Cache-Lindsey 0.001 $\mu\text{g/L}$

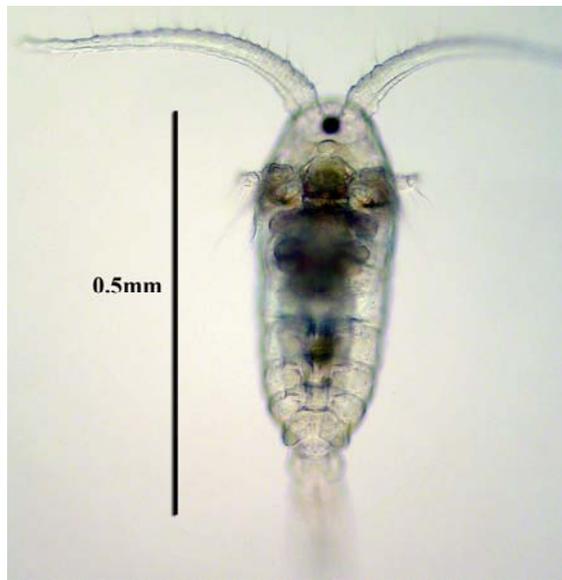
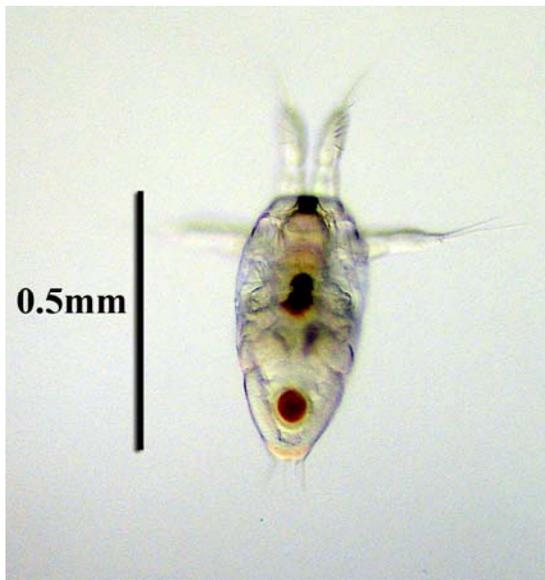
Objectives

- To determine LC10 and LC50 values of copper, unionized ammonia, bifenthrin, cyfluthrin, and permethrin using *Eurytemora affinis*
- To compare sensitivity of *Pseudodiaptomus forbesi* and *Eurytemora affinis* to unionized ammonia

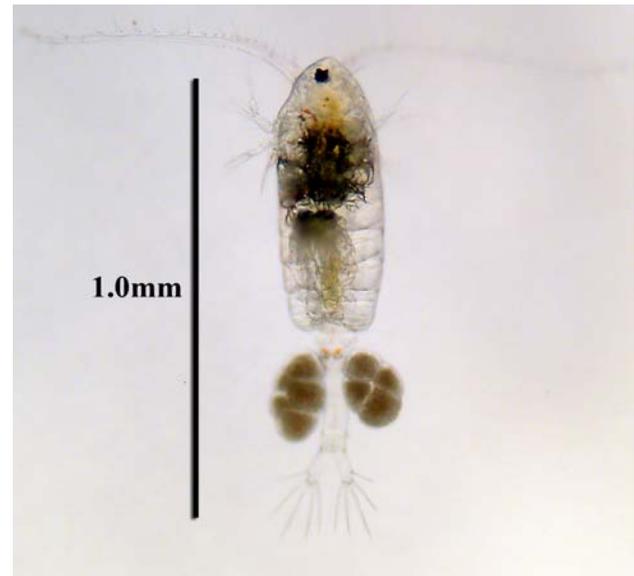
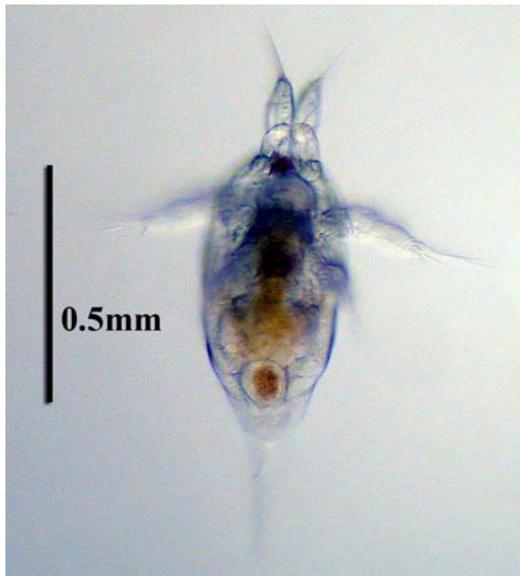
Test Conditions Used for *E. affinis* and *P. forbesi*



Temperature (°C)	20±0.1
Salinity (ppt)	1-2
pH	8.0±0.1
Acceptability in control survival	>80%
Size of test beaker (mL)	600
Volume of test solution (mL)	500
Life stage of copepods	Juvenile
# of copepods	20
# of replicates per concentration	3
# of concentrations	6
Feeding regime	Daily
Static-renewal test Duration	24-96 h



Eurytemora Affinis



Pseudodiaptomus forbesi

96 hours LC10 and 50 values of *E. affinis* using EPA Probit Analysis Program

Chemicals	LC 10	LC 50
Total Ammonia (mg/L; pH 8.1)	7.01 (5.50, 8.71)☉	10.97 (9.76, 11.96)
Unionized Ammonia (mg/L; pH 8.1)	0.46 (0.35, 0.55)	0.78 (0.68, 0.86)
Copper (µg/L; ppb)	1.42 (0.61, 1.45)	3.48 (2.85, 4.15)
Bifenthrin (ng/L; pptr)	3.93 (1.49, 5.99)	13.27 (8.88, 17.60)
Permethrin (ng/L; pptr)	83.37 (38.71, 110.83)	158.08 (125.55, 175.99)
Cyfluthrin (ng/L; pptr)*	1.40 (0.05, 2.89)	12.72 (8.05, 55.55)

☉ 95% confidence intervals are indicated in parentheses

* Need additional test at lower concentration

Total Ammonia at 3 pH Levels

	pH7.2	pH7.6	pH8.1
<i>E. Affinis</i> (Control Survival \geq 88.33%)			
LC10 (mg/L)	1.82 (0, 2.79) [⊙]	5.02 (1.42, 6.85)	7.01 (5.50, 8.71)
LC50 (mg/L)	10.93 (7.34, 49.0)	7.56 (4.07, 8.95)	10.97 (9.76, 11.96)
<i>P. Forbesi</i> (Control Survival \geq 88.33%)			
LC10 (mg/L)	2.77 (1.75, 3.59)	5.16 (1.62, 6.92)*	NA
LC50 (mg/L)	5.87 (4.89, 6.66)	7.68 (4.39, 8.99)*	NA

⊙ 95% confidence intervals are indicated in parentheses

* 72-h data were used

Unionized Ammonia at 3 pH Levels

	pH7.2	pH7.6	pH8.1
<i>E. Affinis</i> (Control Survival $\geq 88.33\%$)			
LC10 (mg/L)	0.011 (0, 0.017) [⊙]	0.08 (0.02, 0.11)	0.46 (0.35, 0.55)
LC50 (mg/L)	0.068 (0.046, 0.306)	0.12 (0.06, 0.14)	0.78 (0.68, 0.86)
<i>P. Forbesi</i> (Control survival $\geq 88.33\%$)			
LC10 (mg/L)	0.017 (0.011, 0.022)	0.08 (0.03, 0.11)*	NA
LC50 (mg/L)	0.037 (0.031, 0.042)	0.12 (0.07, 0.14)*	NA

⊙ 95% confidence intervals are indicated in parentheses

* 72-h data were used

Is water in North and South Delta
affecting the survivals of *E. Affinis*?

Laboratory and Field Testing Data

Chemicals	LC 10	LC 50	North and South Delta	
Unionized Ammonia (pH 7.2)	<i>E. affinis</i> 11 µg/L (0, 17) <i>P. forbesi</i> 17 µg/L (11, 22)	<i>E. affinis</i> 68 µg/L (46, 306) <i>P. forbesi</i> 37 µg/L (31, 42)	Hood 711 Cache-Lindsey Light55	9-25 µg/L 11-29 µg/L 11-13 µg/L 6-11 µg/L
Bifenthrin	3.93 ng/L (1.49, 5.99)	13.27 ng/L (8.88, 17.60)	711 Cache-Lindsey	1 ng/L 1 ng/L
Permethrin	83.37 ng/L (38.71, 110.83)	158.08 ng/L (125.55, 175.99)	ND	
Cyfluthrin	1.40 ng/L (0.05, 2.89)	12.72 ng/L (8.05, 55.55)	ND	
Copper	1.42 µg/L (0.61, 1.45)	3.48 µg/L (2.85, 4.15)	711 Cache-Lindsey 902	2.16-3.01 µg/L 4.10-4.41 µg/L 3.47 µg/L

95% confidence intervals are indicated in parentheses

Conclusions

- *E. Affinis* is very sensitive to copper and ammonia
- *P. forbesi* is more sensitive to ammonia than *E. affinis*
- Survivals of *E. affinis* in our 2008 study are related to the toxic effects of ammonia and copper and to a lesser extent the toxic effects of pyrethroid pesticides
- The lethal concentrations of ammonia for *E. Affinis* and *P. forbesi* are at or below current EPA Water Quality Criteria of 11.23 mg N/L)
- The lethal concentration of copper for *E. Affinis* is below current EPA Water Quality Criteria (13 µg/L freshwater; 4.8 µg/L for saltwater)

Water Quality Criteria of Ammonia in the SFE

■ EPA Aquatic Life Criteria

- is set to protect aquatic organisms from acute and chronic exposure to a toxicant or physicochemical stressors, and
- is based on highest concentration at which organisms can be chronically exposed without any adverse effect

Predicting Ammonia Chronic Criteria of Copepods

Species	Common name	GMACR*
<i>Ceriodaphnia dubia</i>	Water flea	1.9
<i>Daphnia magna</i>	Water flea	5.3
<i>Ictalurus punctatus</i>	Channel catfish	2.7
<i>Micropterus dolomieu</i>	Smallmouth bass	7.4
<i>Lepomis macrochirus</i>	Bluegill sunfish	7.6
<i>Pimephales promelas</i>	Fathead minnow	10.9
	Mean GMACR	5.97
<i>E. Affinis</i> (LC10= 0.011 mg/L) pH7.2; 20°C	(Acute=0.068mg/L)/(GMACR=5.97) = Chronic = 0.011 mgNH₃/L or 1.82 mg N/L	
<i>P. Forbesi</i> (LC10= 0.017 mg/L) pH7.2; 20°C	(Acute=0.037mg/L)/(GMACR=5.97) = Chronic = 0.006 mgNH₃/L or 1.02 mg N/L	

Copepods Chronic Criterion Concentrations (CCC) is below CCC (0.023 mgNH₃/L or 3.78 mg N/L) of USEPA at pH7.2 and 20°C when early life stages of fish are present

* Genus mean Acute chronic ratio (GMACR) was from Table 8 of US EPA 1999 ammonia criteria

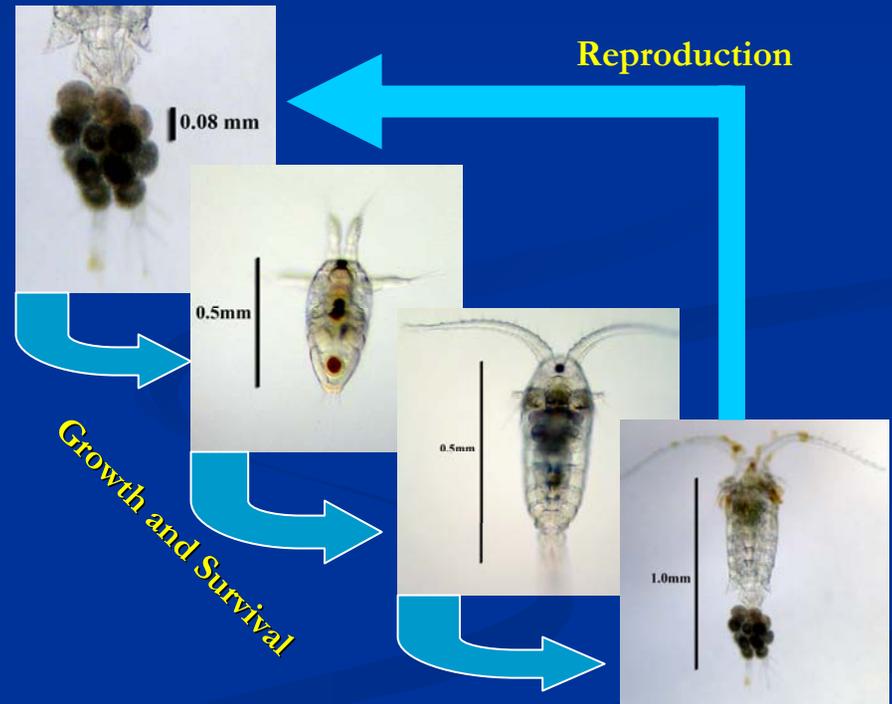
Genus/Species Differences in Responses to Ammonia

- Genus Mean Acute Chronic Ratio
 - Substantially ↑LC50 with ↓temperature in invertebrate
- Species specific
 - *P. forbesi* is more sensitive than *E. affinis*
 - ↓LC50 with ↓pH
 - *E. affinis* ~1.5 fold ↓LC50 pH7.6 to 7.2
 - *P. forbesi* ~3 fold ↓LC50 pH7.6 to 7.2
- Life spans/Life Cycle
 - 60-73d (*E. affinis*) : >180d (*H. azteca*) : >360d (Fish)
 - 19-21d (*E. affinis*) : >30d (*H. azteca*) : >60 d (Fish)

Recommendations

- Acute Chronic toxicity data should be derived on endpoint and length of exposure appropriate to the copepod species
- Life table* assess growth rate potential of a population in various environments should be developed as an ecological meaningful chronic toxicity bioassay

Fecundity (# of broods and Brood size)



* $\sum L_x \cdot M_x \cdot e^{-R_x} = 1$, r = intrinsic rate of natural increase (Lotka 1925)

Summary

- Predicted Chronic Criterion Concentrations for:
 - *E. affinis* = 0.011 mgNH₃/L or 1.82 mg N/L
 - *P. forbesi* = 0.006 mgNH₃/L or 1.02 mg N/L
- Proposed development of actual chronic criteria and life table evaluation of chronic exposure for copepods
- Combination of ammonia and copper is more toxic than either toxicant individually (Herbert and Vandyke, 1964)